# Fact Sheet

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# Power Uprates for Nuclear Plants

**Background**

Utilities have been using power uprates since the 1970s as a way to increase the power output of their nuclear plants. As of July 2004, the NRC has completed 101 such reviews resulting in a gain of approximately 12,548 MWt (megawatts thermal) or 4,183 MWe (megawatts electric) at existing plants (see Table 1). Collectively, an equivalent of about four nuclear power plant units has been gained through implementation of power uprates at existing plants. NRC licensees have indicated they plan to ask for power uprates over the next five years, that if approved, would add another 2,841 MWt (947 MWe) to the nation's generating capacity.

**Discussion**

To increase the power output of a reactor, typically a more highly enriched uranium fuel is added. This enables the reactor to produce more thermal energy and therefore more steam, driving a turbine generator to produce electricity. In order to accomplish this, components such as pipes, valves, pumps, heat exchangers, electrical transformers and generators, must be able to accommodate the conditions that would exist at the higher power level. For example, a higher power level usually involves higher steam and water flow through the systems used in converting the thermal power into electric power. These systems must be capable of accommodating the higher flows.

In some instances, licensees will modify and/or replace components in order to accommodate a higher power level. Depending on the desired increase in power level and original equipment design, this can involve major and costly modifications to the plant such as the replacement of main turbines. All of these factors must be analyzed by the licensee as part of a request for a power uprate, which is accomplished by amending the plant's operating license. The analyses must demonstrate that the proposed new configuration remains safe and that measures continue to be in place to protect the health and safety of the public. These analyses are reviewed by the NRC before a request for a power uprate is approved.

Power uprates can be classified in three categories: (1) measurement uncertainty recapture power uprates, (2) stretch power uprates, and (3) extended power uprates.

**1) Measurement uncertainty recapture power uprates** are power increases less than two percent and are achieved by using enhanced techniques for calculating reactor power. This involves the use of state-of-the-art devices to more precisely measure feedwater flow which is used to calculate reactor power. More precise measurements reduce the degree of uncertainty in the power level which is used by analysts to predict the ability of the reactor to be safely shut down under some accident conditions.

**2) Stretch power uprates** are typically on the order of up to seven percent and usually involve changes to instrumentation settings. Stretch power uprates generally do not involve major plant modifications. This is especially true for boiling-water reactor plants. In some limited cases where plant equipment was operated near capacity prior to the power uprate, more substantial changes may be required.

**3) Extended power uprates** are usually greater than stretch power uprates and have been approved for increases as high as 20 percent. Extended power uprates usually require significant modifications to major pieces of plant equipment such as the high pressure turbines, condensate pumps and motors, main generators, and/or transformers.

**Review Process**

Power uprates are submitted to NRC as license amendment requests. The applications and reviews are complex and involve many areas of NRC including various technical divisions of the Office of Nuclear Reactor Regulation and the Office of the General Counsel. Some reviews may also involve the Office of Nuclear Regulatory Research and the Advisory Committee on Reactor Safeguards. In evaluating a power uprate request, NRC reviews data and accident analyses submitted by a licensee to confirm that the plant can operate safely at the higher power level. Reviews of power uprate requests are a high priority and are therefore, being conducted on accelerated schedules.

Regulatory Issue Summary (RIS) 2002-03, "Guidance on the Content of Measurement Uncertainty Recapture Power Uprate Applications," dated January 31, 2002, covers analyses of the effect of the power uprate on things such as electrical equipment, major plant systems, and emergency operating procedures. The RIS outlines the staff's information needs for reviewing measurement uncertainty recapture power uprate applications and is intended to result in a more efficient and effective review process. Standardization of licensee's submittals, improvements in the quality of submittals, and more focused reviews by the staff could improve the timeliness of power uprate reviews.

Based on results of its industry survey, NRC expects to receive only one stretch power uprate over the next five years. Therefore, NRC's efforts for improving the power uprate application and review processes initially focused on measurement uncertainty and extended power uprates. Efficiencies gained there will be applied to improve the stretch power uprate review process.

Reviews of extended power uprate applications were initially estimated to take up to 18 months, but have been completed more quickly. The Duane Arnold, Dresden 2 and 3, and Quad Cities 1 and 2 extended power uprates were completed in just under 12 months. This included coordination and review with the NRC's Advisory Committee for Reactor Safeguards -- an independent panel of technical experts from diverse fields that advises the Commission.

The NRC issued a review standard for extended power uprates, RS-001, in December 2003. The standard is a first-of-a-kind document that provides a comprehensive process and technical guidance for reviews by the NRC staff, and also provides useful information to licensees considering applying for an extended uprate. The NRC's Advisory Committee on Reactor Safeguards endorsed RS-001 as an "excellent review standard." The staff is currently using this standard to review the proposed 20-percent uprate for Vermont Yankee and the proposed 8-percent uprate for the Waterford Steam Electric Station. The staff will closely monitor these uprate reviews to identify any issues related to using RS-001.

To keep the public informed of its activities, NRC publishes a notice in the *Federal Register* (1) when it receives a request from a licensee for a power uprate, giving the public the opportunity to request a hearing; (2) after a finding of no significant environmental impact is made, if applicable; and (3) if a power uprate is approved. A press release is also issued if a power uprate is approved.

**Current Status**

Plant-Specific Applications Under Review

The NRC usually has several applications for power uprates under review at any given time. An updated list of applications under review can be found on the NRC's Web site at this address: http://www.nrc.gov/reactors/operating/licensing/power-uprates/pending-applications.html .

Steam Dryer Issues Following Uprates

Since 2002, steam dryer cracking and flow-induced vibration damage on components and supports for the main steam and feedwater lines have been observed at the Dresden and Quad Cities nuclear power plants, both of which use boiling water reactors, following implementation of extended power uprates. NRC staff have determined these issues do not pose an immediate safety concern, given the plants' current operating conditions. However, steam dryers and other internal main steam and feedwater components must maintain structural integrity to avoid generating loose parts that could impact safety system or reactor plant operation. The NRC has corresponded with and met with nuclear industry groups concerning these issues since the first occurrences, and continues to examine its regulatory options based on industry actions and the information available.

**Future Actions**

Licensees have told NRC they plan to submit 18 power uprate applications in the next five years as follows:

- 10 extended power uprates
- 1 stretch power uprate
- 7 measurement uncertainty recapture power uprates

Based on the information provided, planned power uprates are expected to result in an increase of about 2,841 MWt. An updated list of anticipated future applications can be found on the NRC's Web site at this address: http://www.nrc.gov/reactors/operating/licensing/power-uprates/expected-applications.html .

**Tables**



**Table 1 - Approved Power Uprates as of June 2004**

(TYPE -- S = Stretch; E = Extended; MU = Measurement Uncertainty Recapture)

| NO. | Plant | % Uprate | Mwt | Year Approved | TYPE |
|---|---|---|---|---|---|
| 1 | Calvert Cliffs 1 | 5.5 | 140 | 1977 | S |
| 2 | Calvert Cliffs 2 | 5.5 | 140 | 1977 | S |
| 3 | Millstone 2 | 5 | 140 | 1979 | S |
| 4 | H. B. Robinson | 4.5 | 100 | 1979 | S |
| 5 | Fort Calhoun | 5.6 | 80 | 1980 | S |
| 6 | St. Lucie 1 | 5.5 | 140 | 1981 | S |
| 7 | St. Lucie 2 | 5.5 | 140 | 1985 | S |
| 8 | Duane Arnold | 4.1 | 65 | 1985 | S |
| 9 | Salem 1 | 2 | 73 | 1986 | S |
| 10 | North Anna 1 | 4.2 | 118 | 1986 | S |
| 11 | North Anna 2 | 4.2 | 118 | 1986 | S |
| 12 | Callaway | 4.5 | 154 | 1988 | S |
| 13 | TMI-1 | 1.3 | 33 | 1988 | S |
| 14 | Fermi 2 | 4 | 137 | 1992 | S |

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|---|---|---|---|---|---|
| 15 | Vogtle 1 | 4.5 | 154 | 1993 | S |
| 16 | Vogtle 2 | 4.5 | 154 | 1993 | S |
| 17 | Wolf Creek | 4.5 | 154 | 1993 | S |
| 18 | Susquehanna 2 | 4.5 | 148 | 1994 | S |
| 19 | Peach Bottom 2 | 5 | 165 | 1994 | S |
| 20 | Limerick 2 | 5 | 165 | 1995 | S |
| 21 | Susquehanna 1 | 4.5 | 148 | 1995 | S |
| 22 | Nine Mile Point 2 | 4.3 | 144 | 1995 | S |
| 23 | WNP-2 | 4.9 | 163 | 1995 | S |
| 24 | Peach Bottom 3 | 5 | 165 | 1995 | S |
| 25 | Surry 1 | 4.3 | 105 | 1995 | S |
| 26 | Surry 2 | 4.3 | 105 | 1995 | S |
| 27 | Hatch 1 | 5 | 122 | 1995 | S |
| 28 | Hatch 2 | 5 | 122 | 1995 | S |
| 29 | Limerick 1 | 5 | 165 | 1996 | S |
| 30 | V. C. Summer | 4.5 | 125 | 1996 | S |
| 31 | Palo Verde 1 | 2 | 76 | 1996 | S |
| 32 | Palo Verde 2 | 2 | 76 | 1996 | S |
| 33 | Palo Verde 3 | 2 | 76 | 1996 | S |
| 34 | Turkey Point 3 | 4.5 | 100 | 1996 | S |
| 35 | Turkey Point 4 | 4.5 | 100 | 1996 | S |
| 36 | Brunswick 1 | 5 | 122 | 1996 | S |
| 37 | Brunswick 2 | 5 | 122 | 1996 | S |
| 38 | Fitzpatrick | 4 | 100 | 1996 | S |
| 39 | Farley 1 | 5 | 138 | 1998 | S |
| 40 | Farley 2 | 5 | 138 | 1998 | S |
| 41 | Browns Ferry 2 | 5 | 164 | 1998 | S |
| 42 | Browns Ferry 3 | 5 | 164 | 1998 | S |
| 43 | Monticello | 6.3 | 105 | 1998 | E |
| 44 | Hatch 1 | 8 | 205 | 1998 | E |
| 45 | Hatch 2 | 8 | 205 | 1998 | E |
| 46 | Comanche Peak 2 | 1 | 34 | 1999 | MU |

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|---|---|---|---|---|---|
| 47 | LaSalle 1 | 5 | 166 | 2000 | S |
| 48 | LaSalle 2 | 5 | 166 | 2000 | S |
| 49 | Perry | 5 | 178 | 2000 | S |
| 50 | River Bend | 5 | 145 | 2000 | S |
| 51 | Diablo Canyon 1 | 2 | 73 | 2000 | S |
| 52 | Watts Bar | 1.4 | 48 | 2001 | MU |
| 53 | Byron 1 | 5 | 170 | 2001 | S |
| 54 | Byron 2 | 5 | 170 | 2001 | S |
| 55 | Braidwood 1 | 5 | 170 | 2001 | S |
| 56 | Braidwood 2 | 5 | 170 | 2001 | S |
| 57 | Salem 1 | 1.4 | 48 | 2001 | MU |
| 58 | Salem 2 | 1.4 | 48 | 2001 | MU |
| 59 | San Onofre 2 | 1.4 | 48 | 2001 | MU |
| 60 | San Onofre 3 | 1.4 | 48 | 2001 | MU |
| 61 | Susquehanna 1 | 1.4 | 48 | 2001 | MU |
| 62 | Susquehanna 2 | 1.4 | 48 | 2001 | MU |
| 63 | Hope Creek | 1.4 | 46 | 2001 | MU |
| 64 | Beaver Valley 1 | 1.4 | 37 | 2001 | MU |
| 65 | Beaver Valley 2 | 1.4 | 37 | 2001 | MU |
| 66 | Shearon Harris | 4.5 | 138 | 2001 | S |
| 67 | Comanche Peak 1 | 1.4 | 47 | 2001 | MU |
| 68 | Comanche Peak 2 | 0.4 | 13 | 2001 | MU |
| 69 | Duane Arnold | 15.3 | 248 | 2001 | E |
| 70 | Dresden 2 | 17 | 430 | 2001 | E |
| 71 | Dresden 3 | 17 | 430 | 2001 | E |
| 72 | Quad Cities 1 | 17.8 | 446 | 2001 | E |
| 73 | Quad Cities 2 | 17.8 | 446 | 2001 | E |
| 74 | Waterford 3 | 1.5 | 51 | 2002 | MU |
| 75 | Clinton | 20 | 579 | 2002 | E |
| 76 | South Texas 1 | 1.4 | 53 | 2002 | MU |
| 77 | South Texas 2 | 1.4 | 53 | 2002 | MU |
| 78 | ANO-2 | 7.5 | 211 | 2002 | E |

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|---|---|---|---|---|---|
| 79 | Sequoyah 1 | 1.3 | 44 | 2002 | MU |
| 80 | Sequoyah 2 | 1.3 | 44 | 2002 | MU |
| 81 | Brunswick 1 | 15 | 365 | 2002 | E |
| 82 | Brunswick 2 | 15 | 365 | 2002 | E |
| 83 | Grand Gulf | 1.7 | 65 | 2002 | MU |
| 84 | H. B. Robinson | 1.7 | 39 | 2002 | MU |
| 85 | Peach Bottom 2 | 1.62 | 56 | 2002 | MU |
| 86 | Peach Bottom 3 | 1.62 | 56 | 2002 | MU |
| 87 | Indian Point 3 | 1.4 | 42.4 | 2002 | MU |
| 88 | Point Beach 1 | 1.4 | 21.5 | 2002 | MU |
| 89 | Point Beach 2 | 1.4 | 21.5 | 2002 | MU |
| 90 | Crystal River 3 | 0.9 | 24 | 2002 | S |
| 91 | D.C. Cook 1 | 1.66 | 54 | 2002 | MU |
| 92 | River Bend | 1.7 | 52 | 2003 | MU |
| 93 | D.C. Cook 2 | 1.66 | 57 | 2003 | MU |
| 94 | Pilgrim | 1.5 | 30 | 2003 | MU |
| 95 | Indian Point 2 | 1.4 | 43 | 2003 | MU |
| 96 | Kewaunee | 1.4 | 23 | 2003 | MU |
| 97 | Hatch 1 | 1.5 | 41 | 2003 | MU |
| 98 | Hatch 2 | 1.5 | 41 | 2003 | MU |
| 99 | Palo Verde 2 | 2.9 | 114 | 2003 | S |
| 100 | Fort Calhoun* | 1.6 | 24 | 2004 | MU |
| 101 | Kewaunee | 6.0 | 99 | 2004 | S |
| 102 | Palisades | 1.4 | 35 | 2004 | MU |

* Fort Calhoun later reduced power to the pre-MU level after being informed of potential instrument inaccuracies in ultrasonic flow meters used in the uprate.

**Table 2 - Power Uprates Currently Under Review as of June 2004**

(TYPE -- S = Stretch; E = Extended; MU = Measurement Uncertainty Recapture)

| No. | Plant | % Uprate | MWt | Submittal Date | Projected Completion Date | Type |
|---|---|---|---|---|---|---|
| 1 | Vermont Yankee | 20 | 319 | 09/10/03 | January 2005 | EPU |
| 2 | Waterford | 8 | 275 | 11/13/03 | January 2005 | EPU |
| 3 | Indian Point 2 | 3.3 | 102 | 01/29/04 | October 2004 | S |
| 4 | Seabrook | 5.2 | 176 | 03/17/04 | TBD | S |
| 5 | Indian Point 3 | 4.85 | 148 | 06/25/04 | TBD | S |
| 6 | Browns Ferry 2 | 15 | 494 | 06/25/04 | TBD | EPU |
| 7 | Browns Ferry 3 | 15 | 494 | 06/25/04 | TBD | EPU |
| 8 | Browns Ferry 1 | 20 | 659 | 06/28/04 | TBD | EPU |
| 9 | Palo Verde 1 | 2.94 | 114 | 07/09/04 | TBD | S |
| 10 | Palo Verde 3 | 2.94 | 114 | 07/09/04 | TBD | S |

**Table 3 - Expected Future Submittals for Power Uprates as of June 2004**

| Fiscal Year | Total Uprates Expected | Measurement Uncertainty Recapture Uprates | Stretch Power Uprates | Extended Power Uprates | Megawatts Thermal | Approximate Megawatts Electric |
|---|---|---|---|---|---|---|
| 2004 | 1 | 1 | 0 | 0 | 24 | 8 |
| 2005 | 7 | 3 | 0 | 4 | 1,291 | 430 |
| 2006 | 3 | 3 | 0 | 0 | 161 | 54 |
| 2007 | 6 | 0 | 1 | 5 | 843 | 281 |
| 2008 | 1 | 0 | 0 | 1 | 522 | 174 |
| **TOTAL** | **18** | **7** | **1** | **10** | **2,841** | **947** |

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